Has Ever Brahmaea Ledereri Rogenhofer, 1873 Inhabited the Colchis Refugium

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Abstract: The biogeographical background. There are two refugial centers in Transcaucasia: Colchis (along the Black Sea coast) and Hyrcan (Hyrcania) (along the Caspian Sea shore). Elements from Europe and Asia and their biogeographical subdivisions compose flora and fauna, which combined with the diverse geomorphology (Laurasian, Gondvanian), the presence of the impressive mountain ridge of the Great Caucasus, its insularity during 100 million years (from Cretaceous time), have resulted in a high taxonomic (species, genera) richness and endemicism. The both refugia characterized by a rather uniform thermal indexes, considerably the former one. The both shelters consist of an extraordinary abundance and diversity of thermophilic woody flora (trees, shrubs and vines) belonging to Arcto-Tertiary Geoflora. Except species typical for nemoral biota, there are extremely rare species of tropical-subtropical origin, which became extinct in South Caucasus during the Tertiary (at the close of the Pliocene) climate deterioration. In response to cooling climate and physiographic changes, some rare genera became restricted to both refugia of Transcaucasia. Most of them are now confined chiefly within the Hyrcanian refugium (species of Albizia, Gleditsia, Panthera, Hystrix). Among the invertebrate fauna of Tertiary origin should be considerably mentioned species of remarkable nocturnal Brahmin moth – Brahmaea Walker. The interdisciplinary study of the orthodox view regarding the vicariant event between two species of moths as though they are indigenous of Colchis (B. ledereri) and Talysh (B. christophi) does not actually exist. The reason circumstances to express such opinion remain important due for a variety of reasons which are given below.

Keywords: Colchis, Hyrcan, Refugia, Biogeography, Brahmaea ledereri

1. Introduction

In the moderate climate belt of the North Hemisphere is represented broad-leaved deciduous, summer-green forest zone (biome). In biogeographical literature, it is determined as a Temperate Broad-Leaved Deciduous Forests (TBDF) [1, 2]. By geobotanists this thermophilic dendroflora are proposed as the Arcto-Tertiary Geoflora [1, 2]. Sometimes TBDF complex mentioned as a Nemoral Flora [3] within these communities participate some warm climate loving summer-green arboreal plants (sweet chestnut, beeches, oaks, zelkova, etc.), conifers (yew tree, tsuga, sequoia, etc.) [4]. After the Pliocene climate deterioration, representatives of the TBDF grow preserving in local places, restricted in refugial areas [5]. Two the largest and richest with the Arcto-Tertiary relics’ regions in the western Eurasia are situated in the south Caucasus and adjacent some countries [6, 8]. One of it, Hyrcanian province (subprovince) includes the Caspian Sea coast area and northern slopes of the Alborz mountains range in North Iran. Its smaller northwestern site, Talysh, represented in the southeast Transcaucasia (Republic of Azerbaijan) [7]. The second large harbor is Colchis. This region, the main part of anEuxinian province (subprovince) covers eastern and southeastern part of the Black Sea (coast area and adjacent slopes of the Greater and the Lesser Caucasus). It includes main part of West Georgia, Krasnodar district of Russia and north-eastern Turkey [6]. All of these regions and districts are present the Caucasus Ecoregion (480.000 sq.km.) [6].

Physical-geographically, the two regions extend from 35° to 45° latitude [6].
Among the Caucasus biomes, the floristic and faunistic diversity and infrequency (relict and endemic plant and animal species) of forests of mentioned two refugia are one of the most striking feature of the Ecoregion [8,9]. The central place of the most humid area is occupied by south Colchis with West Georgia’s province, Adjara (41°21’ and 41°53’N), refugium in refugium, with considerably humid and warm temperate (oceanic) climate. January mean temperatures are above 0°C, and maximum precipitation is known from the Mt Mitrala (‘Crying Mountain’ – from Georgian), namely 4520 mm, which is record data for the Caucasus Isthmus [9], and the Former Soviet Union (FSU).

Figure 1. The typical site of the Mitrala gorge (Adjara). (All photos belong to A. Gegechkori).

Except the narrow sea coastal area, it is typical mountainous district of Georgia, which occupied Adjaro-Imeretian (Meskheti Range) mountain system of the Lesser Caucasus [6]. Adjara with adjacent another province of West Georgia – Guria and neighboring to the northwestern part of Turkey is richest in endemic and relict species. Orographically it is represented as part of Western Lesser Caucasus (WLC), which is largely known as a Major Forest Refugium. WLC belongs to the Eastern Euxinian or Colchianphytogeographic province [10].

If phytocenoses of Talish is favorable with its archaic representatives in the canopy (species of Parrotia, Quercus, Acer) [7-8], the Colchis shelter is impressive with its understory (especially species of Rhododendron) [5].

Derivative forms of relict fauna are an inseparable component of Arcto-Tertiary woody communities of both refugia, especially to Talish. Mentioned should be species of following genera: Brahmaea Walker, Isophya Wattenwyl, Parandra Latreille, etc. [11].

2. Results and Discussion

Endemic and relict species of any refugia are of exceptional biological and biogeographical interests. Refugial centers sheltering such species are frequently referred to as a biodiversity hotspot. They have a prominent role in conservation biology [12].

The most vivid example of relict and at the same time endemic species are manifested by genus Brahmaea (Brahma – the creator, major god of Indian religion) [11,28]. Brahmin moths, family Brahmaeidae, of 28 species are found in the tropical latitudes of Ethiopian and Oriental zoogeographical Regions, and extending north into the warmer area of temperate localities of Palearctic.

The family takes its taxonomic place in superfamily Bombycoidea and consists itself by two subfamilies: Dactylolecitaterinae and Brahmaeinae [13]. Adults of Brahmin moth species are large: wingspan varies from 50 to 180 mm. Species occur in tropical-subtropical biomes have circular ‘eye’ markings on their wings (‘Owl Moths’). This complex of moths regarding to independent genus Brahmaphtalma Mell by some entomologists [14, 15]. The other ones are from temperate climate biomes, without these markings - to Brahmaea (sensusstricto) [16]. The Brahmid moths have most complicated wing patterns of any Lepidoptera [16]. Leaf feeders, larvae are recorded in Asclepiadaceae and Oleaceae [17,18,19].

Brahmaeidae at present include four recognized genera: Brahmaca Walkerr (type genus of the family), genus represented in Oriental and Palearctic Regions (8 species); Acanthobrahmaea Sauter, a monotypic European genus; Calliprogonos Mell, a monotypic Chinese genus; Dactylocerus Mell, an Afrotopical genus of about eight species; by some authors within mentioned family is considered also Loxonia Hübner in Palearctic with about twenty species [20,21,22]. The range of Brahmaea spp. in the temperate climate area is complex, involving several refugia. Present-day as a minimum 5-6 species of this genus have become an endemics of local regions of the Palearctic: B. tancrei Austaut (Russian Far East, Korea), B. certhia Fabricius (Sino-Korean, but from southern China most likely more), B. litsera Hao, Zhang & Yang(northern China), B. japonica (Butler) (from Japan), B. (Acanthobrahmaea) europaea Hartig (from Italy), B. ledereri Rogenhofer (Turkey and adjacent small area of Syria). Hynesian B. christophi Staudinger by some authors treated as a subspecies of B. ledereri [23, 24], subspecies – B. ledereri zabade Freina occurs in extreme easternward of Anatolia (Turkish Kurdistan region). It shows intermediate features between latter two species [25].

Despite mentioned data, the Brahmaeidae seem to have been little studied and literature sources are very scanty [16]. There are apparently 15 species and 4 genera in China alone [16]. Sometimes information about Brahmid moths similar to genera including in Brahmaeidae, are quite controversial. For example, B. ledereri and B. christophi are mentioned in Chinese complex of these moths[14]; then, according to another source, B. ledereri in Chinaamong the other species of this genus feeds on Ligustrum sinense [26].

Therefore, “Eurasiatic species of Brahmaeidae present polymorphic populations with an uneven geographic distribution. The disputed taxonomy of this group is also due to the occurrence of populations that show morphological characteristics intermediate between related species” [20].

Among relict and endemic species of South Caucasus
refugia species of genus *Brahmaea* have emerged as of great interest to biogeographers due disjunct distribution area [7,11] but are there within two refugia – Colchis and Hyrcanvicariant event of Brahmi moths?

It should be stressed that among the relict fauna of Colchis, stenopaleoendemic *B. ledereri* is very problematic species for this region till today. A controversial information of its occurrence in perhumidhabitats of Colchis lowland and foothills arises chiefly from very old, questionable and with a large probability incorrect records. It seems to be doubtful the presence of this species along the eastern and southern Black Sea coast supposedly as a result of wrongly given locality in scientific literature [27]. Lepidopterologist Dr. E. Didmanidze in her’s monograph ‘The butterflies of Georgia’ [28] wrote: ‘In collections of the museum (Georgian National Museum – A.G.) only one specimen of *B. ledereri* is preserved, label of which is ‘1875’ (Romanoff’s collection).’ In another unpublished paper Didmanidze and Goginashvili [30] underline: ‘The first summarized information on Brahmin moths of South Caucasus is summarized by N. Romanoff (1885) [65] in which is indicated *Brahmaealedereri* from “Batumi province”.

The next important information includes the catalogue by Staudinger and Rebel (1901) [29]. In this work as a first site ofBrahmin ledereri’s moth finding, followed to Rogenhofer, who described *B. ledereri*, is named ‘Taur.os’ (with following sites in German language: ‘Gebirgsgebeitvom Bulghar-daghbis Gjaur-daghmit den OrtenHadjin, Zeitun, Marasch and Akbes (Eibes)’ [30].

**Figure 2.** *Brahmaealedereri* from collections of the Georgian National Museum.

Latter existence of a Brahmin moth in Adjara (Batumi) is indicated by famous Russian lepidopterologists Ryabov [31] in his valuable ‘Butterflies of the Caucasus’. This view seems to be ‘turning point’, i.e. a series of articles based misunderstanding, as though the presence of ‘relict moth’ in Western Lesser Caucasus (Adjara). This viewpoint was largely motivated to the former Soviet Union’s entomologists have been manifested ‘everybody and together’: tropical-subtropical fauna including *B. ledereri* of West Georgia as ‘Colchis’ ones. In this context, to show typical erroneous scholarly sources, should be quote Didmanidze [28]: ‘It is very rare species of Tertiary Period and endemic of Colchic (mixed broad-leaved forests – A. G.), included in the ‘Red Book of the USSR’; or ‘on the territory of the Caucasuscoccur only two species of this scanty tropical genus, *B. christophii* one of them’; then ‘on the territory of Georgia lived Colchicbrahmaea – *B. ledereri* Rogenhofer 1873, but after the beginning of XX century, in spite of regular inspection of typical area, this species was not found anymore’. This point of view that this moth could be considered extinct, i.e. Regionally Extinct (RE) in West Georgia is shared by almost all the entomologists of the Caucasus and the former USSR [31,38-44].

Despite of mentioned viewpoint, Lederer’s moth as a live species of Colchis biota is still indicated by some authors [7,11,28,32-37,64].

A complex of reasons has led co-author of the present article [27] to look carefully into the relict distribution of this archaic species upon in humid ecosystems of the Black Sea coastal area.

Colchis as a region is situated in the temperate climate zone supporting temperate and humid biome with broadleaf and mixed forests. It has an extremely impoverishment species of humid-tolerant tropical-subtropical and Mediterranean, sub-arid type of subtropical flora and fauna within this (Colchis) marginal parts of their range (f. e. species of *Hymenophyllum, Arbutus, Erica*, etc.) [41-44]. However, viewed over the entire Quaternary, if any taxa survived glacial-interglacial cycles in Transcaucasia, with a great probability it should be found in a contemporary refugia locations. One of such stable shelter is Colchis forests composed of thermophilic broad-leaf deciduous and coniferous dendraflora. The latter was not endangered through changes in timber composition [5, 9, 10,45, 46].

It is doubtful whether species like *B. ledereri* has become extinct across all Colchis, still less in southern Colchis, i.e. outpost region for many relictual plant and animal species. For example, relict moth *Phasussschamyl*, the salamander of Miocene time *Mertensiellacaucasica*, another ‘dying relict’ (plant) *Epigaegaaultheroides*, and others [28,45-47].

*B. ledereri* unlikely to be extincted because of in South Colchis still exists required to this moth large areas of hygro-thermophilous, close to primeval broadleaf forests with complex habitats.

This is especially true for some gorges of Adjara district, which are really impressive with lush flora, sheltering a number of outstanding ancient living organisms [44-46, 48]. Some of most important from this viewpoint sites are represented as a Natural Parks (Kolkheti National Park, Mitrala National Park) or reserves (Kintrishi State Nature Reserve, Kobuleti State Reserve). Some reserves in Adjara were founded in the 1950s and 1960s, i.e. after 50-60 years later of as though extincted data of *B. ledereri*.

It should be stressed that Mitrala NP (and neighboring other sites) with its Arcto-Tertiary deciduous forests develops as in the extremely moist gorges is more ‘tropical site’ than those of Talysh (Azerbaijan), which shelter another relict species – *B. christophii* [8, 11, 41].

The same requiring habitats of Brahmi moths are largely represented along the neighbouring Turkish Caucasus (part of WLC), in the Pontic Mountains (Pontids) and Lazistan, which runs as a narrow stripe along the same southern coast of the Black Sea. It should be stated that Lederer’s moth is not
recorded in Lazistan till today [49, 50].

Despite Brahmin moth’s official conservation status as Regionally Extinct (RE), sightings are still continuous, though none has been conclusively proven. It should be mentioned two recent attempts of positively decision of this problem. For example, a joint expedition carried out by Zaguliaev (St.-Petersburg), Didmanidze (Tbilisi), Jobaba (Kobuleti, i.e. Adjara). During 3 years (1983-1985) was collected a rich fauna of butterflies including nocturnal moth species [30]. At the same time pictures (photos) of the moth were allotting to residents of different gorges of Adjara to recognize the image, thus being identities unmistakably to this species of Brahmid moth; Jobava himself was ready to take pictures of life-cycle stages of B. ledereri.

Another attempt to collect this species of moth was put into practice in 2010-2011 (in Adjara) and 2012 (in adjacent to Adjara Turkish part of Colchis refugium, Ģoruh River Valley). One of the main goals of expeditions was to collect caterpillars of moth on, as though food plant, Osmanthus decorus in both states. The material was collecting by light trapping (PRK-2 lamps) at night, netting by day, and looking for caterpillars in daytime. In four different elevations of the Kintrishi River Gorge outstanding by its relict species of vegetation light traps were used including constantly operative Sakharov’s insecttrapping. The last trip was granted by the Rustereli National Science Foundation. All these attempts to collect B. ledereri had no results [30].

It is difficult to judge whatever during last century microorganism diseases (fungal and others) through epidemiology can cause severe, demonstrable impact against vulnerable relict invertebrate animal species of Colchis, including Lederer’s moth.

As regards to predators, species of genus Brahmaea, similar to most tropical butterflies, to escape predation, adult insects will hide through mimicry (cryptic coloration: on the example of B. Ledereri the ground color is dark-brown, ornamented with many parallels, finally wary-curly lines of white-rose color). Important cryptic selective advantage provides theirs slow flying (during daytime adults rest on tree trunks). Cryptic anatomy and coloration is exemplified by large caterpillars as well [28].

This fact that ecological parameter of some temperate deciduous forests is attractive for exotic insects is confirmed by colonizing of Colchic ‘rainforest’ with saturnid moth. Duing 20th century western Georgia was enriched with tropical-subtropical Ailanthus silkmoth (Samiacynthia). It was introduced in Georgia for sericulture development. The moth did not domesticate as the silkworm unlike S. cynthiae in India (it is the only completely domesticated silkworm other than Bombyxmori). Indigenous populations of S. cynthiaeoccur in China and Korea. In some countries of all continents, like Caucasus, it escaped from cultivation and naturalized [28]. It ‘adapted to the natural conditions, has become a part of the Caucasian peacockbutterflies fauna and today is distributed in the total subtropical belt of the Georgian Black Sea coastal line’ [28].

According to Ryabov [31], Borodin et al. (Eds.) [33] and Didmanidze [28], Didmanidze and Petrov [40], the caterpillars of B. ledereri feed on Osmanthus (Phillyrea) decorus and as it seems on other arboreal plants of Oleaceae, within the community usually found Castanea sativa in over forest and Alnushbarbetaun and Corylus, in second stratum of forests. The stand of O. decorus usually occurs in subcanopy in Adjara and Guria districts (Georgia) and in the adjacent Turkish Caucasus [48].

This record requires confirmation because of, as it was mentioned, there are no professional entomologists and naturalists who recorded feeding larva, i.e. insect (moth) host plant (O. decorus) associations in West Georgia and Lazistan.

According to Mandajadze [48], O. (Phillyrea) decorus, is evergreen shrub or small tree. It is one of the most-moist-tolerant species of its genus. O. decorusis restricted in Adjara to foothills and low mountain’s slopes. Species typical within the group of noble hardwood include Oriental beech, sweet chestnut, European hornbeam, Oriental spruce, common ash tree (Fraxinus excelsior), Caucasian persimmon; understory is represented by Laurocerasus officinalis, Rhododendron ponticum, Staphylea pinnata, S. colchica, Ilex colchica, Vaccinium arctostaphylos, etc. In marginal parts of forests it forms stands with Colchic boxwood. Therefore, in this community of deciduous forest there are some species of fam, Oleaceae (Fraxinus, Osmanthus), i.e. host plants of the moth.

If we take into consideration this fact that in typical Colchic woody community were organized numerous field excursions from Georgian National Museum and Zoological Institute RAS (St.-Petersburg) supplied by night moth trapping equipment, unlike to Hyrcanian forests, caterpillar-plant interactions research, as it was underlined, gave no positive results.

Finally, an additional confusion regarding the presence ofLederer’s Brahmin in West Georgia should be originated from recent historical toponyms of the Colchis (Kolkheti) region. For example, ‘Pontus’ being an ancient name for the region around the Black Sea, and by extension, for the sea itself (en.wikipedia.org/wiki/Toponymy). Probably, these circumstances motivated entomologists of early 20th to incorrect determine the toponyme of B. ledereri finding site of the moth if it exists indeed. The same situation occurs regarding to principality of Kutaisi. In this principality during the Tsarist Russian Empire (19th) besides Imereti district of West Georgia was included Guria adjacent to Adjara. Hence,
when in the past time for *Osmanthus decorus* was mentioned that this shrub grows in principality of Kutaisi it should be understood not Imereti region (Kutaisi is capital of this district) but Guria just from latter region was described *Phillyrea medwedewii* (i.e. *Osmanthus decorus*) by Sredinski [48]. The same view seems to be based on misunderstanding for lepidopterologists. For example, they are emphasized as first collecting sites of discussed moth Batumi city (capital of Adjara – A.G.) vicinity [30,40], or moth’s distribution in ‘Adjara and Lazistan’ [40], and believe that ‘species is distributed in western Georgia, Colchis lowland. It is described from the Black Sea coast area (Lazistan) and inhabits in the same habitats, Colchic forests’ [31], it is ‘endemic and relict species of Pontic Province’ [40], ‘endemic of Colchis’ [32, 33], ‘endemic of Colchis and adjacent territory of the Black Sea coast of Turkey’ [34], ‘Colchis B. ledereri and Talyshian *B. christophi*’ [35], ‘Adjarian B. ledereri’ [37, 64], etc.

Based on entomologists’ data, now Lederer’s moth is included in all regional (Caucasus, former USSR) and international (IUCN) Red Data Books and Red Lists [30, 42].


*B. ledereri* is enough to became sure

The insect prefers the most damp and shady forests of gorges at the Talysh mountain from lowland up to 1,000m a.s.l, i.e. the environment of its inhabitationwillmore or less resemble of that of the subtropical-warm and humid climate of ancient geological epochs, when the waters of the Sarmatian Sea washed the coastal zone of the Caucasus Peninsula. The single glance at the genus *Brahmaea* is enough to became sure of how rich and lush thermophilous woody communities covered the Caucasus at the boundary of the Paleogene and Neogene Periods. Similar to Iran, Christoph’s moth caterpillars feed on the leaves of native ash-tree (*Fraxinus excelsior coriariifolia*) [35]. Belonging to the relicts of immemorial time (about 30 mya), *B. christophi* close to extinction (Critically Endangered, CE) [37, 53].

A few publications refer to studies of the peacockbutterflies and considerably family Brahmaeidae of Northern Iran [54-56]. As a relict species of Miocene time *B. christophi* now present in only a few populations in the Hycranian region (mentioned sources and pers. Observ. – A.G.). Present information was collected from local naturalists, from collections of museums of local National Parks during excursion of Gegechkori in Caspian forests (2012, X).

In Northern Iran this species occurs both in mesophilous Hycranian forests and more xeric variant of the same forests nearby to open woodlands and scrubs in Golestan Province northern of Golestan National Park (GNP).

One of the most xeric location of distribution *B. christophi* occurs near Totli Tamak village. This village and its surroundings are located northwestern part of GNP (300m away of NP border, northwestern Iran (620m a.s.l.) (Soufi, pers. comm.), annual precipitation ranging from 220 to 280 mm (Khorozyan, pers. comm.). Precipitation increases to 400mm at the slopes of the Bylikooh Mountain area, which is adjacents to mentioned village (Soufi, pers. observ.).

The local semi-lush forest, where the new emerging Christoph’s moth was recorded (900m a.s.l., mentioned mountain area), consists of leading species of noble hardwood of Hycranian region. Major forest-building species include: *Quercus scastaneifolia, Parrotiapersica, Carpinus betulus, Fraxinus excelsior ssp. coriariifolia; Diospiros lotus, Ficus

The most vivid example of relict and at the same time endemic species are manifested by *Brahmaechristophi*, one of the most beautiful moths in the invertebrate fauna of the extreme south-east Caucasus and Northern Iran [27-28, 30-44, 51-55].

*B. christophi* much resembles Turkish vicarious species – *B. ledereri*, but is slightly larger (the wing-span reaches 110-130 mm (maximum – 160mm) vs *B. christophi* (95-107 mm) [28]. The latter species cover the whole Hycranian area, including Iranian part of the southern Caspian basin (Gilian, Mazandaran, Gorgan). The co-author of present work collected some specimens of this species with lepidopterologists R. Effendi and E. Didmanidze during several excursions in 1970s. At present four specimens of the moth are deposited in the collections of Georgian National Museum (Azerbaijan, Astara: 1910; Talysh, Hycranian relict forest, 14.04. 1974 (leg. Gegechkori), 17.04.1974 (leg. Didmanidze) [30].

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*Figure 4. Brahmaechristophi – new emerged from pupa imago (photo by M. Soufi, 2013).*
*hyrcana* are represented as subcanopy trees; *Populus caspica*, *Alnus glutinosa*, *Salix* spp. are confined in riverine; *Crataegus spentagina*, *C. monogyna*, *Mespilus germanica*, *Prunus divaricata*, *Danae racemosa* frequently occur as understory in these communities. The ground vegetation is manifested by the presence of *Primula heterochroma*, *Viola alba* (Soufi, pers. comm., pers. observ.).

In adjacent semi-dry habitat mentioned communities are largely outcompeted by more xerophilous communities of *Zelkova carpinifolia* and *Pyrus boissieriana*. In the more xeric variants of the site is phytocenoses, where the leading species are shrubs like *Paliurus spina-christi* and *Rhamnus pallasii* (pers. observ.).

The flight of the moth is observed in April, at night. In daytime adults (the imago) were observed resting with wings spread out on a tree trunk of the dominant forest tree, chestnutleaf oak.

**Figure 7.** The trunk of the magic oak (*Quercus castaneifolia*) near TotliTamak village (about 900m a.s.l.).

Adult of *B. christophi* was observed after emerging from the pupa in the spring, which already indicate the species can permanently bread in not far of rural landscapes situated in the borderland near GNP. This site has now been rather intensively utilized for agriculture and logging. Thus, at present it occurs regularly in this locality.

The species is endangered by changes in forestry management in non-preserved sites of the moth’s range (Soufi, pers. comm.).

In collections of the museum of GNP is exhibited one specimen of *B. christophi*. It was taken in 1980 by ranger also from transition zone of NP. TangeGol similar to TotliTamak village, it is characterized by mosaic semi-lush and semi-dried landscapes.

**Figure 8.** *Brahmaea christophi* (upper specimen) in collection of the Museum of Golestan National Park.

German and Austrian scientists (Gutleb and Wieser) have discovered Cristoph’s moth in TangeGol (2001) as well (Soufi, pers. comm.).

From mentioned peculiarities can be concluded:

1. Unlike all other species of the genus *Brahmaea*, *B. christophi* in the Iranian part of the Hyrcanian subprovince is ecologically most plastic species. It inhabits both Gilan-Mazandaran humid ‘rainforest’ and semi-dry, northeastern part of Iran (northern of GNP); it occurs on the one hand in undisturbed non-urban sites of GNP and some other reserves, and on the other hand in area represented in surrounded by modern homogenous rural land; GNP provide a meeting area for the Caspian Sea coastal and foothills taxa with semi-arid mountain taxa of living organisms, e.g. in the case of the transition zone between the Euro-Siberian (with Euxino-Hyrcanian province) and Irano-Turanian taxa.

2. Outside conservation area, occupying sub-xerothermic sites on the border of National Park and severely reduced numbers in typical habitats population of Christoph’s moth are highly endangered.

Currently, as it was already mentioned, Talysh (Azerbaijan) and adjacent Caspian Sea coastal area of Iran represent relict ecosystems of summer-green warm temperate forests i.e. Major Forests Refugium, sheltering many rare and endangered species including stenopaleo endemics of plants and animals. As unique biome including unique forest composition and floristic and faunistic richness worldwide, it is urgent goal of environmentalists to synergize all activities in order to conserve native biodiversity like, for example, Hyrcan and Golestan National Parks. Therefore recognizing of having great value to strict conservation and management policies, it is urgent need to establish Iran-Azerbaijan cross- and transboundary cooperation for Hyrcan highly complex biodiversity conservation [57].

**Figure 9.** The pristine forest of Hyrcanian refugium, Mazandaran province.

On the other hand, review of literature sources and private findings of Freina [23,25] in southwestern, eastern and southeastern Turkey have make the further light on distribution pattern of *B. ledereri*. His research on taxonomy [23], chorology and biology [25] of the moth showed following: firstly, the range of moth includes part of Western Asia, mainly Asia Minor (Turkey) and adjacent small part of Syria. Therefore, this range does not encompass the Northern Anatolian Mountains, i.e. Pontic Mountains and their northern, far more humid or perhumid slopes that face to the Black Sea (annually rainfall in Lazistan ranges from 2000-3000 mm per
year), and then, Western Transcausia (south Colchis); secondly, the moth’s range in Asia Minor is characterized by disjunct distribution (see map): a) population of Central Taurus Mts, i.e. mountain complex dividing the Mediterranean coastal region of southern Turkey (prov. Antalya) from the central Anatolian plateau; b) population of the upper reaches of the Euphrates River (Eastern Anatolia); c) population of surrounding the city of Elazig (Eastern Anatolia); d) population of Hakkari Province (the southeastern corner of Anatolia) and adjacent Syria. The largest range of discussed moth is represented in Central Taurus Mts, where B. ledereri was collected together with other moths, Saturnia pyri, Nola ronkayorum, etc. [58]; thirdly, ecological requirement of B. ledereri in mentioned sites of Turkey is quite different from those of represented in hygro-mesophilous relict mixed forests of Colchis. In Asia Minor this species prefers chiefly deciduous forests limited by riparian gallery forest represented in riversides of gorges and valleys of local mountains. Dominant vegetation composed of woody species, such as Fraxinus excelsior, Platanus ssp., Eleagnus angustifolia, secondary wild grapevine (Vitisvinifera), fig tree (Ficuscarica), hazel-nut (Corylus spp.), etc. As a result of human activities surrounding landscapes in some regions support only sparsely treed forests consist of overstory deciduous and evergreen species of oak (Quercus infectoria, Q. libani, Q. persica). Understory represented by species of Crataegus, Prunus, Lonicera, Sorbus, Juniperes and others. Leaf feeding caterpillars are found only on ash tree (F. excelsior).

Figure 10. The distribution sites of Brahmaea ledereri Rogenhofer, 1873 in southern Caspian basin area and Anatolia plateau: a) Brahama ledereri ledereri Freina de, Taurus Mts population; b) the same subspecies population in the upper reaches of Euphrates River (site Tanyeri); c) the same population in Elazig; d) B. ledereri zhabaFreina de, population from Hakkari; e) B. ledereri christophi [Sgr] from Alborz and TalyshMts area [25].

It seems that in studied area Lederer’s moth occurs from 1,000 to 2,000m a.s.l. The lower amplitude of altitudinal distribution of the moth found in the central Taurus (1,000-1,600m), the highest elevation moth reaches occurs about 1,800m (upper reaches of the Euphrates River), and in Hakkari province the altitudinal distribution areas varies from 1,200 to 1,650m.

Riparian forests, which are surrounded by xeric shrublands and patches of sparsely forested sites, dramatically reduced by human’s activity from the historical past. Thus, this is a wide spectrum of semi-arid habitats with clearly expressed sub-Mediterranean climate (Taurus Mts) location (a) and continental climate locations (b,c), or sharply expressed continental climate (very hot and dry summer and cold winter) location (d) sites of Turkey (see fig. 1).

Vicariant event, in which part of a once widely distributed population of Brahmid moth becomes isolated in a spacially localized patches in Turkey, should be explained by intense folding of the Anatolian plateau. This tectonic event that caused this local landmass to emerge and largely change its morphology is the eastward displacement of the Anatolian microplate, driven from the northward displacement of the Arabian plate [59], considerably after rising Anatolian diagonal, which caused the separation of East and West Anatolian biota [60].

Current distribution area of Lederer’s moth is considered with suggestion of Tarkhnishvili et al. [10]. From these authors, viewpoint during Last Glacial Maximum climates suitable for forest vegetation existed in six regions of western Asia: Colchis, western Anatolia, western Taurus, and upper reaches of the Tigris River, Levant and the southern Caspian basin. Currently, among named six regions the most biodiverse area of the forests is represented only in Colchis and Hycania but other four regions are almost treeless, although, as it seems, deforestation within the Fertile Crescent region, i.e. cradle of agriculture caused by human activity [61]. Now only in some gorges of Anatolia plateau survive the derivatives of former mesic forests just in these microrefugial shelters are found some forest biome dependent invertebrate fauna including B. ledereri. Thus, current range of two sister species of Brahmaea (B. ledereri and B. christophi) have shaped an area from southern Caspian basin to the headwaters of the Euphrates and on the other hand to the Mediterranean basin (Central Taurus).

According to Freina [25], the possible range of B. ledereri is not investigated in adjacent to eastern Anatolia, northern Iraq and Zagros Mountain range (Iran). Did the mesic forests actually occur during LGM in the Zagros Mts, which currently have covered by quite different biomes in result of the xerophilization of the whole region? Neontological data support the presence of isolated refugia in the central Zagros Mts, i.e. in the Irano-Turanian part of Iran. In this site of range at an altitude of 1,730 m a.s.l., annual precipitation about 600-700mm and with very cold winter, but much of winter precipitation is snow, which cover the area until the end of March. In this area was discovered disjunct stand, remnant population of Pierocaryapterocarpa (P. fraxinifolia) [62].

At first glance this extraordinary discovery confirms that in Late Tertiary some gorges of Zagros Mts were not extensively influenced by continental climate and were covered by thermophilous Arcto-Tertiary communities of plants resemblance of Euxino-Hyrcanian forests. Hence, these mountainous systems as a natural bridge between Alborz and Taurus Mts have provided to be effective area to harbor some relict representative of the Tertiary biota including with a high
proportionality B. ledereri. In other words Zagros Mts might have played a role of transitional area to connect the Hycanian refuge center of the Caucasus Ecoregion with those of cryptic glacial refugia of Asia Minor and other regions of the Near East.

On the base of the present (real) and imaginative (speculative) distribution of two species of the genus Brahmaea should be proposed the following range of the moth: in a southern Caspian Sea area (northern Iran) on the one hand, and Anatolia plateau on the other hand. Within large refugium two taxa are concentrated from Alborz Mts (in general Hycania), then throughout with larger probability of the occurrence in a dry segment of the Zagros Mts, and via extreme eastern part of the Anatolia plateau to the Taurus Mts (upper reaches of the Euphrates River), almost adjacent to its western part of the Mediterranean Sea.

The present-day distribution of two taxa of Brahmaea reflects a history of past wide distribution of tropical-subtropical and Arcto-Tertiary biotas, which today is largely replaced by modern, increasingly impoverished Hycanian nemoral biota and Anatolian Turkey plateau’s semi-deserts with gorges sheltering some remain of former TBDF forests.

As we see this disjunct range of two species of the genus Brahmaeais distinguished by various climatic characteristics, the orographic heterogeneity, the geological and edaphic conditions as well as human impact considerably in Fertile Crescent area.

Among above indicated six regions, where the scientists hypothesize the presence of forest refugia there, the largest and most forested, major refugia is Colchis.

Therefore, in westernmost stretches of the Transcaucasia, in Colchis as well as in Hycania, an independent population of Brahmaea should be survived. This region with northern slopes of Pontic Mts undoubtedly satisfy the relict moth’s ecological requirements. But today the eastern and south-eastern Black Sea coastal area should be considered as the region outside the confirmed refugium, where Brahmaea moth truly survived. On the other hand, without paleontological data there is no reason to postulate that some bottleneck event took place on the territory of Asia Minor.

Thus, recognizing this assumption as though B. ledereri lived in Colchis appears to be erroneous, I [27] hypothesize an extreme version of scenario to formation of the range of both paleoenemic taxa of Brahmin moths in Asia Minor and southern Caspian basin (Hycania). Under the most likely simulation regarding to origin of the common ancestor of ledereri-christophie evolutionary lineage should be occurring within four or five forested or suggested mesic forest vegetation regions of Western Asia, most of which are represented today as cryptic refugia. Among six LGM refugial regions B. ledereri should be excluded from Colchis refugium. At the same time we once more emphasized that there are no abiotic factors, which made it an endangered and extinct species.

Floristic and faunistic studies of Indo-Malayan and other tropical origin species of Hycanianrefugium (species of Albizia, Gleditsia, Panthera (including P. tigris, P. pardus), Hytrix, Brahmaea, etc.), support a viewpoint of the above modelling simulation.

There are some other explanations, which should be used as an additional suggestions for my [27] personal view. For example, geographical (latitudinal) and biogeographical (hystorical) reasons. In general, for all mentioned thermophilous tropical-subtropical species from northern margin of the tropical-subtropical latitudes (i.e. Hycanian part of Iran and Azerbaijan Republic) Colchis temperate climate latitudes with its abiotic factors, including, except temperature and precipitation, also photoperiodism, are insuperable ecological and geographical (latitudinal) barrier, preventing further northward distribution of Brahmaea’s autoecology organisms. It is worthy to remember, that the Hycanian refugium is located 4°c5° southward thanthat of the Colchis refugium.

Unlike Colchis, for a long time of historical past, south and south-eastern Asia, as a part of Oriental zoogeographic region, was an important contributor to the Hycanian part of northern Iran provided northern territories with thermophilous tropical species [7, 63].

This straight biological connection between two remote regions was shifted during the current (Quaternary) series of large-scale environmental changes (glacial events) causing desertification of some regions of Near East including central and eastern parts of the Iranian plateau. This dryland area converted into bottlenecks to decrease the potential to expansion of thermo- and hygrophilous species in some marginal areas of higher latitudes of subtropic and subtropic-temperate border areas.

Thus, few species of the ancient genus Brahmaea (some species of which are found in tropics and subtropics) are scattered now within such remote but from climatic viewpoint more or less similar (except part of Golestan province of Iran and Anatolian Plateau) places of Northern Hemisphere.

On the example of allopatrically dispersed species united in genus Brahmaea, could be provided valuable information for our understanding of global climate changes patterns, its influence of living organisms eliminations and surviving processes, the role of harbours – refuge – during major Ice Ages in preservation some archaic thermophilous plant and animal taxa of Tertiary Period [27].

3. Conclusions

Comprehensive analysis of vicarious event between two species of Brahmid moths – Brahmaea ledereriand B. christophi as though occurring in two refugia of Transcaucasia, Colchis and Talysh, opened new views and permit provide another conclusions. Here, on the base of research the ranges of two species of peacockbutterflies and their biocenosis, carrying out mainly by some entomologists [23,34-35] we pointed out another relation between Euxin-Hycanian and Anatolian biotas. There are actually allopatric ranges of two relict species of moths, but the disjunction has occurred not between relict moths of Brahmeidae of Colchis and Hycanan
refugia, as it was accepted as an unconditionally dogma among Soviet Union’s entomologists. Split the common range of genus Brahmaea, as it seems, actually took place in geological past (Pliocene), although not between Transcaucasian two famous refugia – Colchis and Talysh but between Hyrcanian refugium and Anatolian preventing penetration complex of subtropical (Hyrcanian/Anatolian) organisms including improvements.

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Soufi and his family are appreciated for support of my trip to Transcaucasian two famous refugia – Colchis and Talysh but geological past (Pliocene), although not between

of genus among Soviet Union’s entomologists. Split the common range of light (photoperiodism) became unsuitable for one of the main abiotic factors - seasonal (insufficient) cycles of light is available for the same complex of other organisms during year-round.

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